

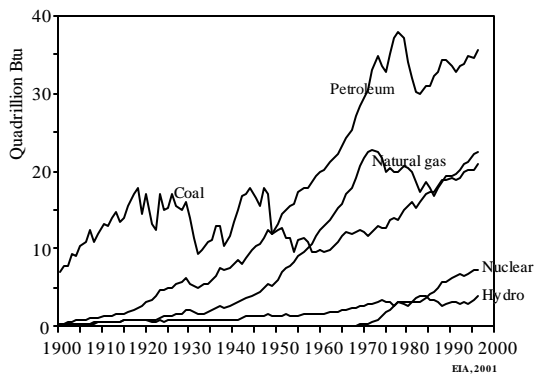
## Announcements

- Exam on Thursday. Same format and covering material since Exam 3
- If you are happy with 1<sup>st</sup> 3 midterm grades, you do not have to take exam 4
- Cumulative Final is Dec. 12, 10-12 in NC 1535.
  - Use midterms as study guides
  - Review session Dec. 7

## Some thoughts/review about energy

- Nested ecosystems and energy flow
  - Scale of cell, organism, ecosystem, biosphere
  - Denver as an ecosystem
- Ultimate source of energy at all these scales
  - Fossil fuels: renewable or non-renewable?
  - Alternative fuels
- Environmental/ecological impacts of various energy sources

The US has grown dependent on inexpensive fossil fuels



## World Petroleum Consumption

• World Total (BBO/year):	26.9
• <b>United States:</b>	<b>6.9</b>
• Japan:	2.0
• China:	1.5
• FSU:	1.4
• Germany:	1.0
• <b>California:</b>	<b>~0.8</b>
• Italy:	0.7
• France:	0.7



## World Oil

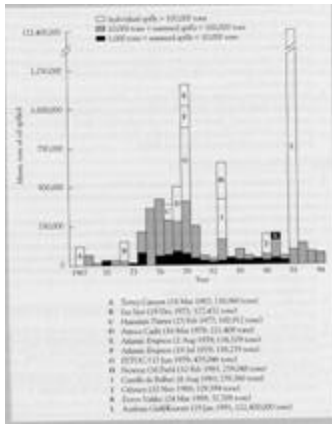
- ◆ World Petroleum Reserves are at all time high (5X larger than at end of WWII, 1945)
- ◆ Remaining Reserves (IHS, 1/96) ~891 BBO, ~1,100 BBO as of 1/1/2001)-Increase of 15%
- ◆ Increase of 36% using 2003 O&J Data (includes 175BBO from Canadian tar sands)
- ◆ Currently Consuming about 28 BBO / Year
- ◆ Oil and Gas Discoveries increased in the 90's
- ◆ Discoveries increased in U.S. last 5 years



## The Coming Oil Crisis?



- ◆ “...young men will live to see (oil production) come to its natural end” ---Pennsylvania State Geologist, 1885
- ◆ “...the peak of production will be passed within three years”--- D. White, Chief Geologist, USGS, 1919
- ◆ “the peak of production will be reached in 1989”---Campbell, 1989;
- ◆ “prior to 2000”---Campbell, 1994;
- ◆ “in 2004”---Campbell, 1997;
- ◆ “in 2010” “very dire...most people die” ---Campbell, 2000



Oil spills since 1967

## Cleanup On The Water

- Boom comes in many sizes, shapes, and types and is used primarily to deflect and/or collect oil.
- Skimming is a mechanical system for removing oil from the surface. This process was created based on the property that oil is lighter than water.
- Burning: Fresh oil contains gases which are very volatile. By igniting these gases whole oil slicks can be reduced to tarry residue.
- Dispersants are used to do just that, disperse. They are chemicals that break-up oil into smaller and smaller particles. Potentially into individual molecules.

## Skimming

- skimmers all are based on the simple principal: oil is lighter than water.
- Oil floats on the surface of water and thus if a way can be found to remove the top layer, oil can be collected easily.
- Skimmers are designed to take the oil off the top of the water. The most common types pull oil off the surface, separate it from most of the water that is also collected, and hold it in a storage tank.

## Dispersants

- Many experts agree that sending the oil into the water column has negative effects on fish, plants, and small animals that use or live in the water.
- If all steps are properly executed, and conditions are adequate, dispersants do a good job of keeping oil off beaches.
- Here is where debate begins: Is oil more harmful on the beaches or dispersed in the water column?

## Primary ways oil injures wildlife

- The oil gets on the fur and feathers and destroys the insulation value. Birds and mammals then die of hypothermia
- They eat the oil, either while trying to clean the oil off their fur and feathers or while scavenging on dead animals.
- Smaller organisms can be smothered by a thick layer of oil washing ashore.
- Oil also changes the physical environment for plants and animals by forming asphalt-like pavements, sometimes altering the environment so extensively that the organisms can no longer survive in their old habitat.
- The oil impacts them in ways that does not lead to a quick death, such as damaging the liver, causing blindness, or reproductive failure (chronic/sublethal responses). An impaired animal cannot compete for food and avoid predators.

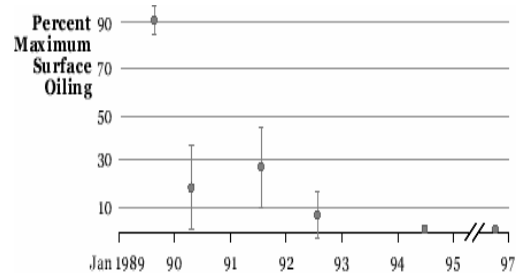
## Cleanup On The Alaskan Beaches

- Bioremediation: the application of certain fertilizers to beaches stimulates the growth of "oil-eating" microbes.
- Hot Water & High Pressure: cleanup crews blast oil off beaches into the water where it can be skimmed off.
- Chemical Cleaning: in an attempt to avoid Hot Water & High Pressure treatment, chemical cleaners were tested which removed oil from the beach for collection.
- Manual treatment incorporates the use of shovels, rakes, absorbent materials and human hands.
- Mechanical Treatment: tractors, backhoes, front-end loaders, and other machines were used to move beach and scoop up asphalt collections.

## Bioremediation

- Bioremediation is the application of fertilizers to increase the number of oil - eating microbes.
- To promote the acceleration of microbe production in Prince William Sound it was decided to apply nitrogen and phosphorus to the shorelines.
- A study on the application on Green Island concluded that fertilizers were effective and could be dilute enough to minimize environmental effects. By the end of the summer up to 110 miles of beaches had been treated using bioremediation.
- Following Exxon Valdez, it took a mere three months for bioremediation to go from the concept stage to the widespread application stage and it became a widely accepted treatment.

## Decline in beach oil through time



## Impacts of treatment

- We now know that our attempts to clean up an oil spill can also indirectly cause harm to some of the resources we are trying to protect.
- For example, using hot water or chemicals to remove oil can harm plants and animals
- simply sending a team of cleanup workers into an oiled area can trample sensitive organisms and mix oil more deeply into a beach.

## Recovery of Wildlife in Alaska (1998)

Recovery Unknown	Not Recovering	Recovering	Recovered
Cutthroat Trout Wilderness Areas Dolly Varden Kitlitz's Murrelet Rockfish	Common Loon Cormorants Harbor Seal Harlequin Duck Killer Whales Pigeon Guillemot	Archaeological Sites Black Oystercatcher Clams Common Murre Tidal Communities Marbled Murrelet Mussels Pacific Herring Pink Salmon Sea Otter Sediments Sockeye Salmon	Bald Eagle River Otter

- Deeply penetrated oil continues to visibly leach from a few beaches.
- In some areas, intertidal animals such as mussels are still contaminated by oil.
- Some rocky sites that were stripped of heavy plant cover by high-pressure, hot-water cleaning remain mostly bare rock.
- Rich clam beds that suffered high mortalities from oil and extensive beach cleaning have not repopulated to their previous levels.

Longer-term impacts?

## Arabian Gulf Spill

- ~40-4000 x more oil than Exxon Valdez
- \$60 million (\$2 billion Valdez)
- 500 workers (11,000 workers Valdez)

## Arabian Gulf Spill - general impacts

- birds, mammals, sea snakes, and some turtles killed by fouling and suffocation
- 80% decrease in bird numbers
- on beach, deep penetrating oil created anoxic zones
- decrease in water temperatures (from smoke)
  - marine organism life cycle greatly tied to seawater temperature
  - could lead to reproductive failure in many marine invertebrates
- increased water metal conc. 0 - 800%

## Alternative to Fossil Fuels

- Nuclear
- Hydroelectric
- Hydrogen fuel cells
- Wind
- Solar
- Wave
- Tidal
- Heat
- Geothermal
- Biomass
- Diesel
- Garbage

## Why are Reservoirs constructed?

- "In the simplest sense, we build dams for the same reason we wear coats in the winter: to exert control over an aspect of an environment that would otherwise make living difficult or even impossible. If a valley is subject to destructive flooding, we dam its river. If the desert is dry, we build a lake."
- Many reasons to build a dam:
  - Water storage to quench municipal, agricultural, and industrial thirsts
  - Flood control and improved navigation
  - Sediment trapping
  - Water quality improvement
  - Electrical power generation
  - Recreation, aesthetic, and wildlife considerations

## General Facts

- Most dams were built during the 1900's
- There are more than 75,000 dams in the US over 6 feet high
- 3% of land is covered by reservoirs
- Dam building in the US has slowed because few good sites remain
- Worldwide, there are over 36,500 dams over 15 meters high
- The environmental impacts of reservoir creation are large, but poorly understood
- Dams fragment rivers and streams, alter the environment, and impede migration
- BUT dams create reservoirs which can provide new aquatic habitats

## New vehicle opportunities and advantages ...

- ✍ On-board fridge for champagne – 500 W
- ✍ Power tools – 2kW
- ✍ Power an RV – 5 kW
- ✍ Beach barbecue for daughter's wedding – roast ox, disco, light, heaters – 15kW
- ✍ Download movies from satellites
- ✍ Power the electrical demand of 5 houses (during blackouts?)
- ✍ Receive payments from grid for electricity
- ✍ Remote cool-down and heating before entering vehicle
- ✍ Power an outdoor play/pop concert
- ✍ Melt snow around your car to get out of driveway
- ✍ Power outdoor hot tub for 12 on skiing holiday
- ✍ Downtown access on 'bad pollution days' (Europe, Mexico, etc)
- ✍ "Guilt-free" motoring

Source: Adapted from Shell Hydrogen, April 2000

## Garbage to energy

- Americans are producing more and more waste with each passing year. In 1960, the average American threw away 2.7 pounds of trash a day. Today, the average American throws away 4.4 pounds of trash every day! What are we going to do with all that trash?
- One solution is to burn it. All organic waste contains energy. Organic waste is waste that is made from plant or animal products.
- People have burned one type of organic material for millions of years. Can you guess what that material is?
- It's wood.
- Today, we can burn garbage in special plants and use its heat energy to make steam to heat buildings or to generate electricity. This may sound amazing, but it is really nothing new. More than half of electric power companies already burn another type of solid material to make electricity.
- That material is coal. Coal is a mineral that was formed from the remains of plants that died millions of years ago. Power companies use the heat energy in coal to make electricity.
- Today, there are 103 waste-to-energy plants in the United States. Plus, there are another 26 old-style solid waste incinerators. These old-style incinerators simply burn trash to get rid of it. They do not use the heat energy to make steam or electricity.
- Today, the U.S. burns 17 percent of its solid waste—16 percent in waste-to-energy plants and one percent in old-style incinerators.